NOTICE

All drawings located at the end of the document.

WORK PLAN

ACTINIDE LOADING ANALYSIS FOR THE ACTINIDE MIGRATION STUDIES AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

February 6, 1998

Rocky Flats Environmental Technology Site
Golden, Colorado 80402

RMRS
Rocky Mountain Remediation Services, L L C
protecting the environment

CONTENTS

INTRODUCTION

Purpose

The purpose of this work plan is to provide a framework for conducting actinide loading analysis in surface water on the Rocky Flats Environmental Technology Site (Site) to support actinide transport modeling for the Actinide Migration Studies (AMS) The AMS is being implemented to investigate the mobility of plutonium, americium, and uranium in the Site environment The goal of the AMS is to answer the following questions in the order of urgency shown

1 Urgent What are the important actinide migration sources and migration processes that account for recent surface water quality standard exceedances?
2 Near Term What will be the impacts of actinide migration on planned remedial actions? To what level do sources need to be cleaned up to protect surface water from exceeding action levels for actinides?
3 Long Term How will actinide migration affect surface water quality after Site closure? In other words, will soil Action Levels be sufficiently protective of surface water over the long term?
4 Long Term What is the long term off-site actinide migration, and how will it impact downstream areas (e g accumulation)?

These questions will be answered by mathematical modeling of actinide transport processes to predict actinide loads attributed to known sources of actinides in the Site environment Actinide loading information is needed to calibrate the models, verify modeling results, and evaluate the error of estimation for the models

Scope

The actinide transport models will estimate the quantities of actinides transported to surface water via the environmental pathways as listed below

- Runoff / Diffuse Overland Flow,
- Surface Water Flow (Channeled),
- Groundwater Transport - both saturated and unsaturated,
- Interflow (i e near surface, saturated flow), and
- Airborne Transport

The actinide loading analysis is focused on the Channeled Surface Water Flow transport pathway

Analysis of available surface water discharge and actinide activity data from Site monitoring programs will be done to compute actinide loads on a storm-specific and annual basis to account for changes in transport phenomena associated with changing hydrologic conditions (e g years with normal, higher than normal, or lower than normal precipitation) The loading analysis will be done for logical Site watershed sub-basin nodes which are coincident with locations of stream gaging and runoff sampling stations

The results of this analysis will be used to calibrate actinide transport models to Site conditions and to enable computation of the error of estimation for the transport models In addition, estimates of runoff coefficients will be made to compare to output from hillslope erosion and surface-water transport models

Data Sources and Description

Data for this analysis will come from the following Site monitoring programs

- Event-Related Surface Water Monitoring Program, 1991-1994,
- Industrial Area IM/IRA Monitoring Program, 1995-Present,
- Rocky Flats Cleanup Agreement (RFCA) Monitoring Program 1996-Present, and
- Source Evaluation and Preliminary Mitigation Program 1997-Present

Automated stormwater monitoring equipment has been used since 1991 to collect stormwater runoff samples from Site drainages The equipment consists of a continuously recording flow meter linked to an automatic water sampler which draws a composite sample from the stream when the flow meter indicates that desired flow conditions exist (e g rising stream due to stormwater runoff) The equipment may be programmed to collect samples on either time-paced (e g one sample every 15 minutes) or flow paced (e g one sample every 100 cubic feet) intervals The instrumentation may be programmed in many different ways to collect water samples representing various hydrologic conditions such as baseflow, runoff, or a combination of the two

Since 1991, the Site has continually improved its ability to accurately measure stream discharge and stormwater runoff flows, with the most marked increases in accuracy occurring in 1994 Therefore, loading computations for years prior to 1994 should be regarded as estimations with considerable uncertainty and potentially large errors In a similar fashion, the minimum detectable activity (MDA) for actinides was reduced from approximately 0 08 picocuries per liter (pCi/L) to a range of 0 01 - 0 02 pCi/L over the same time frame These are important qualifications of the data quality and comparability that might limit the usefulness of earlier (i e 1991-1993) data

Changes in sampling methodology from 1991 to present also affect the accuracy and applicability of the loading computations For example, in 1991-1992 sampling was focused on event-related (stormwater) monitoring, and samples were collected over the entire duration of stormwater runoff events During 1993-1995, the stormwater samples were collected on the rising portion of the stormwater runoff hydrograph to represent the poorest water quality during the first flush of the storm events, thereby increasing the possibility of detecting actinides in the surface water

From 1991 to 1995, baseflow water-quality was virtually ignored because water-quality compliance monitoring results showed actinide activities below the Site-specific discharge standards, often times below the MDA Initiation of the Rocky Flats Cleanup Agreement in 1996 brought changes to the monitoring program through the Integrated Monitoring Plan Starting in 1996, the sampling has been done by constant flow-paced collection of composite water samples to provide a continuous measurement of flow-weighted water quality over all hydrologic conditions (e g baseflow as well as stormwater runoff) The continuous flow-paced samples provide the best representation of the total load measured at each gaging station

Study Area

The study area includes the Woman Creek, Walnut Creek, and South Interceptor Ditch (SID) drainage basins, the SID being contained in the Woman Creek watershed (Figure 1) The study area is limited to the Site property from the west fence line to the east fence line, and extends east to higher order water bodies downstream from the Site Data are limited or do not exist for thorough computation of actinide loading to off-Site water bodies, but projections will be made based on monitoring done at the Site east fence line

Data Compilation

The data used for this study will come from Site stream gaging stations shown on Figure 1 The data will include the parameters listed in Table 1 The required resolution for the data are also shown in Table 1

Table 1 —Data needs for actinide loading analysis in support of AMS modeling activities

Parameter	Required Resolution for Analysis
continuous stream discharge	0 1 cubic feet per second (cfs)
stream discharge for each water-quality sample	+/- 5%
plutonium-239,240 (Pu-239,240),	0 02 pCi/L
americium-241 (Am-241)	0 02 pCi/L
uranium-233,234 (U-233,234)	0 02 pCi/L
uranium-238 (U-238)	0 02 pCi/L
total suspended solids	10 mg/L
drainage areas tributary to each gaging station	0 5 acres
precipitation data	0 05 inch, 15-minute record

These data will be compiled in Excel™ spreadsheets for computation of the actinide loads

Data Analysis

Actinide and suspended solids loads will be calculated using Equation 1 The loads will be computed for each gaging station over the period of record available for each station

Equation 1 Load (mass/time) = K*Q*[actinide],

where

Load = a "mass flow," commonly called "flux" in units of mass per unit time (e g μg/year),

K = a constant for appropriate unit conversion,

Q = stream discharge, in Liters / second, and

[actinide] = actinide concentration in μg/L (converted from activity using activity/mass ratio)

The estimations of suspended solids and actinide loads at each gaging station will be used to compute total annual yield (i e total mass) of suspended solids and actinides transported to each station (Equation 2) The yields will be compared spatially to locate actinide source and deposition (sink) areas The yields will also be used to calibrate and verify erosion and AMS sediment and actinide transport models

Equation 2 Yield (mass) = Load * time,

Figure 1 —Locations of Rocky Flats Environmental Technology Site Gaging Stations, Sub-Basins, and Watersheds

The expected loading from extreme runoff events will be evaluated The Rocky Flats Drainage and Flood Control Master Plan (circa 1993) contains modeled flood flows for the 5, 10, 25, 50, and 100-year precipitation events These runoff quantities will be used in conjunction with the loading computations to estimate the actinide transport that might be expected to occur under extreme hydrologic conditions Discharge and water-quality data for the May 17, 1995 flood, available at selected Site gaging stations, will be used to verify the loading estimates for flood flows

It will be useful to calculate the suspended solids and actinide yields per unit drainage area for calibration and verification of the transport models Therefore, the same drainage sub-basins that are used to compute the actual historic yields per unit acre should also be used for modeling transport processes in order for direct comparison of the monitoring results to the modeling results

The maximum allowable load that will produce water-quality in compliance with current Site-specific discharge standards will be computed by multiplying the standard by the monthly and annual discharge at each station This estimate will lead to quantifying the amount of actinide that could remain in Site soils without impacting water quality with respect to the current standards under normal conditions Similar estimates will be made for extreme events such as the May 17, 1995 storm event

Quantification of Uncertainty

It is important to quantify the uncertainty in estimating annual load and yield values The uncertainty in these parameters may be computed using the uncertainties associated with measuring surface-water actinide activity, total suspended solids (TSS) concentrations, and stream discharge to provide a range of expected values

An analytical error term is supplied with each radiochemical analysis The analytical error represents two standard deviations from the expected mean activity for each sample, based on the Poison Distribution No error of estimate is supplied with the TSS or stream discharge data Therefore, the error associated with these measurements must be estimated by independent methods

Discharge measurements at the Site are normally made using Parshall flumes, H-flumes, cutthroat flumes, v-notch weirs, and rectangular weirs It is generally accepted by numerous authors that the error of Parshall flumes is about +/- 5%, and the error for weirs are estimated to be slightly less than Parshall flumes There also is error in the calibration of the flow meters and in estimating discharge for periods with missing data These errors cannot be specifically quantified Therefore, for this study, the error term for all discharge measurements will be estimated at +/- 10% to account for the error associated with the theoretical ratings for the primary devices (e g Parshall flume) plus instrumentation calibration and flow estimation error

The error in the TSS measurements will be quantified by evaluating a duplicate sample data set The number of duplicate samples for TSS in Site surface waters are limited, but such a data set will be compiled to determine the relative percent error in making these analytical measurements

It is assumed that the error terms are additive Therefore, the overall uncertainty will be calculated as follows

$$\text{Uncertainty of Load or Yield Calculation} = +/- (U_{constituent} + U_Q)$$

where $U_{constituent}$ = Uncertainty for radiochemical of TSS analysis, and
U_Q = Uncertainty for stream discharge measurement

Sensitivity Analysis

The computation of loads and yields is sensitive to both the flow measurements and the radiochemical measurements Each of these measurements vary by orders of magnitude The loading computations will be evaluated to determine which component (i e flow or activity (concentration)) controls the sensitivity in the calculations For example, if flow varies over an order of magnitude, but activities vary by a factor of two, then the calculation of load and yield would be more sensitive to the flow measurements than the radiochemical measurements

Schedule

The loading analysis project will begin on February 9, 1998 and finish no later than March 1, 1998 in support of the schedule for AMS modeling of soil erosion and surface-water transport processes (Figure 2)

Deliverables

Results of the analysis will be published in a succinct interpretive report The report will contain tables and graphs displaying the following information

- Average estimated suspended solids and actinide loads and yields for each gaging station for various time intervals including storm-specific, monthly / seasonal, annual, and extreme event-related periods

-

- The estimated loads will be plotted versus relative downstream position to evaluate source and deposition areas

- Estimates of the suspended solids and actinide yields will also be expressed as annual yield per unit area (e g mg/acre)

- Estimates of the maximum quantities of actinides (per unit area) that might remain in Site soils and result in maintenance of acceptable surface-water quality will be provided   A similar analysis will be done for extreme runoff events

Figure 2.—Schedule

Figure 2 —Schedule for the Actinide Migration Study Erosion Modeling Tasks

ID	Task Name	Duration	Start	Finish	Resource Names		1998							
						Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	**Soil Erosion/Surface Water Transport Modeling**	**73d**	**11/19/9**	**2/27/98**	**Chromec**									
2	***Mass Loading Work Plan***	19d	11/19/9	12/15/97	Wetherbee									
3	***Surface Water Loading Analysis***	55d	12/15/9	2/27/98	Wetherbee									

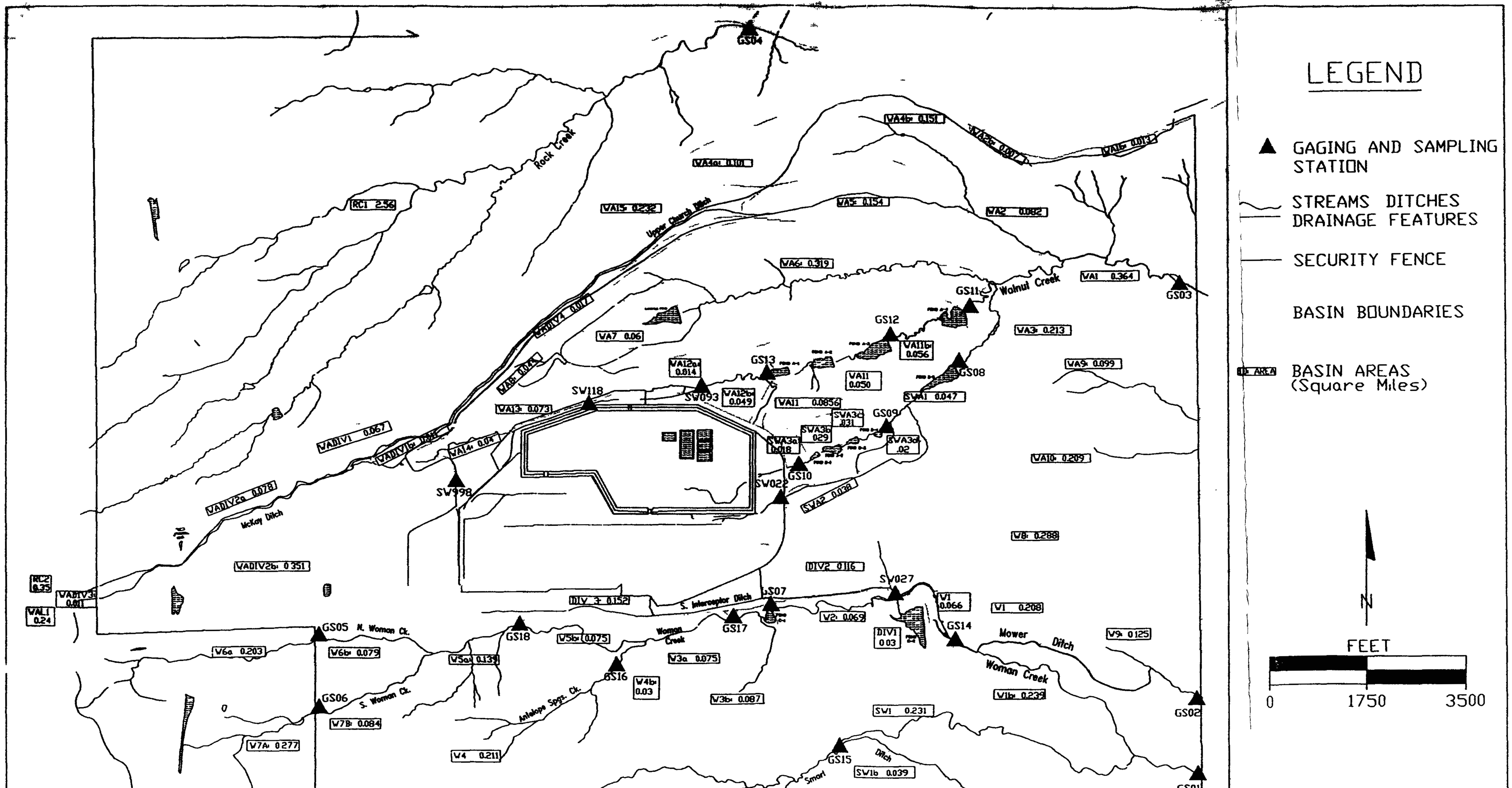

Figure 1
RFETS Gaging Station Network Buffer Zone Drainage Basins and Stormwater Monitoring Locations